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The Influence of Total Disc Arthroplasty Baseplate Design on Energy Transfer to the Vertebral Endplate
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Introduction: Degenerative disc disease is the leading cause of pain and disability in the US. Total disc replacement (TDR) has been introduced to provide pain relief while maintaining spinal mobility. However TDR stability and migration have been of particular concern. The purpose of this study was to determine the initial stability and resistance to migration of TDR baseplate designs in compression and shear using energy methods.

Materials and methods: Baseplate designs representative of TDR baseplates under evaluation or market approval were evaluated for this study. The first design encompasses a large central tapered keel (LK). The second design displays a smaller central keel (SK) with a “saw-tooth” profile. The third design possessed a convex domed shaped (DM) base plate with sequentially reduced ellipses comprising the dome. None of the devices possessed a bone ingrowth texture. For each design six bovine lumbar vertebrae were contoured to accept the device. For the LK and SK devices, endplates were milled flat and a keel fabricated with the aid of a hand held cutting tool. In the case of the DM baseplate, a sanding tool was used to create a concavity within the central region of the vertebral endplate.

Compression loading was applied using a sinusoidal load from -30N to -300N at a frequency of 1Hz for 500 cycles. For anterior/posterior shear, a compressive pressure of 103kPa was applied in order to maintain contact between the baseplate and the vertebral body while an anterior/posterior sinusoidal load of ±100N was applied.

Continuous load and deflection data was recorded after the first 10 cycles and at 25 cycle intervals thereafter. The energy was computed using the area under the load versus deformation curve at each cycle interval and was subsequently averaged for each device geometry. Non-linear curve analysis was applied and fitted curve parameters were compared using 1 way ANOVA with a Tukey post-hoc analysis for comparison between designs.

Results: In compression, both the DM and SK designs displayed comparable energy dissipation initially and at the Plateau value and were statistically different from the LK design (P< 0.05 for both). However, the K value for the SK was significantly reduced as compared to the DM and LK devices (P< 0.05 for both). This would indicate that the SK device requires a longer time to achieve a state of equilibrium within the realm of energy transfer. The DM device initiated a large initial energy and then subsequently achieved a rapid settling. In shear, all three baseplate designs displayed statistically different initial values (P< 0.05 for all).

Discussion: The rate of energy dissipation or slope of the regression line indicated that the LK design resulted in a positive energy value indicative that less energy was required to achieve the desired mechanical loading condition. Such a consequence would indicate that the shear force dissipated more energy posteriorly than in the anterior direction. In addition, the DM devices displayed a statistically significant reduction in the rate of energy dissipation relative to the SK devices. Clinical data will be required in order to validate this new energy concept with respect to the evaluation of motion sparing devices and their mechanical performance.